

REMARKS

The applicants thank the Examiner for the careful examination of this application and respectfully request entry of the amendments indicated hereinabove.

Claims 1-50 are pending and rejected. Claims 2 and 15 are deleted and Claims 1, 3, 7, 14, 16, 17, 19, and 20 are amended hereinabove.

x Amended Claim 1 positively recites that the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of hydrogen, oxygen, and fluorine. These advantageously claimed features are not taught or suggested by the patent granted to Han et al.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc). Furthermore, the Applicants submit that the claimed invention is preferable to Han et al. because a plasma without oxygen does not entirely clean the photoresist and polymeric residues from the wafer.

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claim 1 and respectfully assert that Claim 1 is patentable over Han et al. Furthermore, Claims 14, 21, 27, 28, and 29 are allowable for depending on

allowable independent Claim 1 and, in combination, including limitations not taught or described in the references of record.

X Claim 40 positively recites that the first material is reactive with oxygen plasma. These advantageously claimed features are not taught or suggested by the patent granted to Han et al.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc). Therefore, Claim 40 is patentable over Han et al.

Claims 3-13, 16-20, and 22-26 are allowable for depending on allowable independent Claim 1 and, in combination, including limitations not taught or described in the references of record. Amended Claim 1 positively recites that the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of hydrogen, oxygen, and fluorine. These advantageously claimed features are not taught or suggested by the patents granted to Han et al. and Kropewnicki et al., either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

Kropewnicki et al. also teaches away from the advantageously claimed invention. The Applicants respectfully traverse the Examiner's statement that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the use of a dry clean process (col. 1, line 66 through col. 2, line 44). The Applicants also respectfully traverse the Examiner's statement that Figures 4A-4C relate to the removal of sidewall residual polymer using wet cleans. Kropewnicki et al. uses Figures 4A-4C to describe the formation of the low k layers (which involve some wet processing to create them) and the cleaning of these layer with their dry (plasma) process (col. 7, line 53 through col. 9, line 61).

Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). The Applicants downstream plasma tool operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer. Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

The Applicants submit that it is not obvious to combine Han et al. with Kropewnicki et al. because Kropewnicki teaches away from the use of the wet clean process. Furthermore, it would not be obvious to use a gas mixture of O, H, and F, in the process taught by Kropewnicki et al. because the etcher O₂ process taught by Kropewnicki et al. strips the C from the SiO₂ material.

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claims 3-13, 16-20, and 22-26 and respectfully assert that they are allowable for depending on allowable independent Claim 1 and, in combination, including limitations not taught or described in the references of record, as detailed hereinabove.

Claim 30 positively recites that the first material is reactive with oxygen plasma. Claims 31-36 are allowable for depending on allowable independent Claim 30 and, in combination, including limitations not taught or described in the references of record. These advantageously claimed features are not taught or suggested by the patents granted to Han et al. and Kropewnicki et al., either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

Kropewnicki et al. also teaches away from the advantageously claimed invention. The Applicants respectfully traverse the Examiner's statement that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the use of a dry clean process (col. 1, line 66 through col. 2, line 44). The Applicants also respectfully traverse the Examiner's statement that Figures 4A-4C relate to the removal of sidewall residual polymer using wet cleans.

Kropewnicki et al. uses Figures 4A-4C to describe the formation of the low k layers (which involve some wet processing to create them) and the cleaning of these layer with their dry (plasma) process (col. 7, line 53 through col. 9, line 61).

Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). The Applicants downstream plasma tool operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer. Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

The Applicants submit that it is not obvious to combine Han et al. with Kropewnicki et al. because Kropewnicki teaches away from the use of the wet clean process. Furthermore, it would not be obvious to use a gas mixture of O, H, and F, in the process taught by Kropewnicki et al. because the etcher O₂ process taught by Kropewnicki et al. strips the C from the SiO₂ material.

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claim 30 and respectfully assert that Claim 30 is patentable over Han et al. and Kropewnicki et al, either alone or in combination. Furthermore, Claims 31-36 are allowable for depending on allowable independent Claim 30 and, in combination, including limitations not taught or described in the references of record.

Claims 41-46 are allowable for depending on allowable independent Claim 40 and, in combination, including limitations not taught or described in the references of record. Claim 40 positively recites that the first material is reactive with oxygen plasma. These advantageously claimed features are not taught or suggested by the patents granted to Han et al. and Kropewnicki et al., either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

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Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). The Applicants downstream plasma tool operates in a completely different regime that

includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer. Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

The Applicants submit that it is not obvious to combine Han et al. with Kropewnicki et al. because Kropewnicki teaches away from the use of the wet clean process. Furthermore, it would not be obvious to use a gas mixture of O, H, and F, in the process taught by Kropewnicki et al. because the etcher O₂ process taught by Kropewnicki et al. strips the C from the SiO₂ material.

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claims 41-46 and respectfully assert that they are allowable for depending on allowable independent Claim 40 and, in combination, including limitations not taught or described in the references of record, as detailed hereinabove.

Claims 22-26 are allowable for depending on allowable independent Claim 1 and, in combination, including limitations not taught or described in the references of record. Amended Claim 1 positively recites that the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of hydrogen, oxygen, and fluorine. Claim 22 positively recites that the gas is a mixture having at least 50% hydrogen. These advantageously claimed features are not taught or suggested by the patents granted to Han et al., Kropewnicki et al., and Chien et al., either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

Kropewnicki et al. also teaches away from the advantageously claimed invention. The Applicants respectfully traverse the Examiner's statement that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the use of a dry clean process (col. 1, line 66 through col. 2, line 44). The Applicants also respectfully traverse the Examiner's statement that Figures 4A-4C relate to the removal of sidewall residual polymer using wet cleans. Kropewnicki et al. uses Figures 4A-4C to describe the formation of the low k layers (which involve some wet processing to create them) and the cleaning of these layer with their dry (plasma) process (col. 7, line 53 through col. 9, line 61).

Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). The Applicants downstream plasma tool operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer. Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

The Applicants submit that it is not obvious to combine Han et al. with Kropewnicki et al. because Kropewnicki teaches away from the use of the wet clean process. Furthermore, it would not be obvious to use a gas mixture of O, H, and F, in the process taught by Kropewnicki et al. because the etcher O₂ process taught by Kropewnicki et al. strips the C from the SiO₂ material.

Chien et al. teaches away from the advantageously claimed invention of the gas mixture including at least 50% hydrogen because Chien et al. teaches that the best reaction rates are 19-25% (col. 7, lines 7-19). Furthermore, the Applicants submit that Chien et al.'s teaching of multiple step processing in the same tool teaches away from the Applicants' invention because of the damage that would be experienced by the open metals in dual damascene structures of two or more metal levels (which is the Applicants' application). The Applicants assert that the damage incurred by the device with the processes taught by Chien et al. is quite significant and is not a viable approach for manufacturing copper wired wafers (having low k dielectric materials FSG and OSG).

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claims 22-26 and respectfully assert that they are allowable for depending on allowable independent Claim 1 and, in combination, including limitations not taught or described in the references of record, as detailed hereinabove.

Claim 30 positively recites that the first material is reactive with oxygen plasma. Claims 36-39 are allowable for depending on allowable independent Claim 30 and, in combination, including limitations not taught or described in the

references of record. Claim 36 positively recites that the gas is a mixture having at least 50% hydrogen. These advantageously claimed features are not taught or suggested by the patents granted to Han et al., Kropewnicki et al., and Chien et al., either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

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wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

The Applicants submit that it is not obvious to combine Han et al. with Kropewnicki et al. because Kropewnicki teaches away from the use of the wet clean process. Furthermore, it would not be obvious to use a gas mixture of O, H, and F, in the process taught by Kropewnicki et al. because the etcher O₂ process taught by Kropewnicki et al. strips the C from the SiO₂ material.

Chien et al. teaches away from the advantageously claimed invention of the gas mixture including at least 50% hydrogen because Chien et al. teaches that the best reaction rates are 19-25% (col. 7, lines 7-19). Furthermore, the Applicants submit that Chien et al.'s teaching of multiple step processing in the same tool teaches away from the Applicants' invention because of the damage that would be experienced by the open metals in dual damascene structures of two or more metal levels (which is the Applicants' application). The Applicants assert that the damage incurred by the device with the processes taught by Chien et al. is quite significant and is not a viable approach for manufacturing copper wired wafers (having low k dielectric materials FSG and OSG).

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claims 36-39 and respectfully assert that they are allowable for depending on

allowable independent Claim 30 and, in combination, including limitations not taught or described in the references of record.

Claims 47-50 are allowable for depending on allowable independent Claim 40 and, in combination, including limitations not taught or described in the references of record. Claim 40 positively recites that the first material is reactive with oxygen plasma. Claim 47 positively recites that the gas is a mixture having at least 50% hydrogen. These advantageously claimed features are not taught or suggested by the patents granted to Han et al., Kropewnicki et al., and Chien et al, either alone or in combination.

Han et al teaches away from the advantageously claimed invention of oxygen plasma by repeatedly stating that their invention is directed to the use of oxygen free plasma (col. 5, lines 14, 40, 44, 49, etc).

Kropewnicki et al. also teaches away from the advantageously claimed invention. The Applicants respectfully traverse the Examiner's statement that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the use of a dry clean process (col. 1, line 66 through col. 2, line 44). The Applicants also respectfully traverse the Examiner's statement that Figures 4A-4C relate to the removal of sidewall residual polymer using wet cleans. Kropewnicki et al. uses Figures 4A-4C to describe the formation of the low k layers (which involve some wet processing to create them) and the cleaning of these layer with their dry (plasma) process (col. 7, line 53 through col. 9, line 61).

Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). The Applicants downstream plasma tool operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer. Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Applicants further assert that the Kropewnicki et al. process strips the C from the SiO₂ (or MSQ) dielectric material, causing the loss of the low k characteristic of the material.

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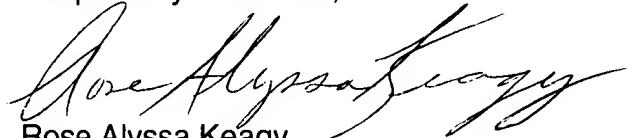
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and is not a viable approach for manufacturing copper wired wafers (having low k dielectric materials FSG and OSG).

Therefore, the Applicants respectfully traverse the Examiner's rejection of Claims 47-50 and respectfully assert that they are allowable for depending on allowable independent Claim 40 and, in combination, including limitations not taught or described in the references of record, as detailed hereinabove.

For the reasons stated above, this application is believed to be in condition for allowance. Reexamination and reconsideration is requested.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

1. A method of fabricating an electronic device formed on a semiconductor wafer, comprising the steps of:

forming a layer of a first material in a fixed position relative to the wafer, wherein the first material has a dielectric constant less than 3.6;

forming a photoresist layer in a fixed position relative to the layer of the first material;

forming at least one void through the layer of the first material in response to the photoresist layer, thereby forming a polymeric residue in response to the photoresist layer; [and]

subjecting the semiconductor wafer to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer; and

removing the polymeric residue, the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of hydrogen, oxygen, and fluorine.

3. The method of claim [2] 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a wet etch chemistry.

7. The method of claim [2] 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid.

14. The method of claim [2] 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a dry plasma.

16. The method of claim [15] 1:
wherein the hydrogen in the mixture is provided from a hydrogen source selected from a group consisting of H₂, NH₃, N₂H₂, H₂S, and CH₄; and
wherein the fluorine in the mixture is provided from a fluorine source selected
5 from a group consisting of CF₄, C₂F₆, CHF₃, CH₂F₂, SF₆, CH₃F, and NF₃.

17. The method of claim [15] 1 wherein the mixture further comprises an inert gas.

19. The method of claim [2] 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of at least 50% hydrogen, and approximately 2-20% oxygen and approximately 2-6% fluorine.

20. The method of claim [2] 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a mixture of approximately 80% NH₃, approximately 10-15% N₂, approximately 2-7% O₂, and approximately 2-6% CF₄.